

Surgical Treatment of Atherosclerotic Lesions of the Subclavian Artery

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■ *Of eight patients with atherosclerotic lesions (seven occlusive, one aneurysmal) of the subclavian artery, five were operated upon because of the subclavian steal and three for severe ischemia of the hand and fingers.*

Removal or bypass of these lesions was uniformly successful in relieving symptoms. In most cases transcervical carotid-subclavian saphenous vein bypass graft is the treatment of choice, provided no carotid obstruction exists or, if there is obstruction, it can be dealt with at operation.

ARTERIOSCLEROTIC LESIONS of the subclavian artery, though considerably less common than carotid or lower extremity lesions, may produce ischemic syndromes involving the cerebral and upper extremity circulation. This report details the clinical course, the distinctive ischemic syndromes, and results of surgical therapy in patients operated upon for subclavian arterial lesions.

Clinical Material

In the period from 1968 to 1970, eight patients with atherosclerotic lesions of the subclavian artery were operated upon at Stanford Medical Center. Clinical data are summarized in Table 1. There were six women and two men. The age range was 32 to 73 years, the average 55 years. Five patients had symptoms and radiographic signs related to the cerebral circulation, the so-

called "subclavian steal." The symptoms most frequently noted were ipsilateral ataxia, vertigo, syncope, decreased vision of the left eye, and transient ipsilateral weakness of the arm—symptoms referable to ischemia of the hindbrain. Three patients had symptoms and signs referable to severe ischemia of the ipsilateral upper extremity. Of these three patients, two had obstructive lesions (Cases 1 and 6), and one had an aneurysm with emboli to the fingers (Case 4). All patients underwent arch aortogram and angiography of the cerebral circulation. In only one of the eight patients were significant obstructive lesions of the other main extracranial cerebral vessels found; five lesions were found in the left subclavian and three in the right.

Surgical Treatment

Four patients underwent endarterectomy (three transthoracic, one transcervical), one aorto-subclavian bypass, one had resection and grafting of the proximal left subclavian for aneurysm, and two had transcervical bypass, one to the distal brachial and one to the subclavian artery

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Submitted, revised, August 13, 1971.

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TABLE 1.—Data on Eight Cases of Subclavian Reconstruction

Case No.	Sex	Age	Symptoms	Physical Exam	X-ray Study	Operation	Result
1.	M	66	Vertigo, blackout spells	110 syst. L. arm 140 syst. R. arm ↓ vision L. eye	Subclavian steal on L. 90% stenosis L. subclav.	Transthoracic L. subclavian TEA	No further spells 4+ L. radial pulse 36 mo. follow-up
2.	F	62	"Subclav. steal" vertigo, severe hypercholesterolemia	50 mm difference, R & L arm B.P. 1+R, 2+L radial	R. subclav. obst. total; distal fills from R. vertebral; narrowed L. subclav.	R. transcervical subclav. TEA	4+ radial pulse R. arm. B.P. > than L. 24 mo. follow-up
3.	M	52	Weakness R. arm, vertigo to right	R. arm B.P. 90 syst. L. arm 170	R. subclav. steal stenosis L. vertebral	Ao-R subclav. bypass with 10 mm dacron graft	B.P. 160 R. & L.; no R. arm claudication; 20 m. follow-up
4.	F	32	Intermittent ischemia fingertips	L. supraclavicular mass	Saccular L. subclavian aneurysm	L. vertebral ligated, aneurysm replaced with 8mm dacron graft	4+ L. radial; B.P. 120/86, 12 mo. follow-up
5.	F	55	Syncope	1+ R. radial pulse	Localized obst. R. subclav. at innom. takeoff	R. subclav. TEA	No syncope, 4+ right radial pulse, 9 mo. follow-up
6.	F	73	Tender fingers L. hand	Gangrene L. index finger, ischemia L.	90% L. subclav. stenosis, 90% stenosis L. vertebral, ulcerated lesion, L. carotid	L. carotid TEA, L. carotid-subclavian bypass	Gangrenous changes gone in 5 days, warm hand, good pulse, 6 mo. follow-up
7.	F	37	↓ vision L. eye, vertigo with exercise L. arm, lupus	1+ L. radial pulse, ↓ B.P. L. arm	90% stenosis takeoff L. subclavian, subclavian steal	Transthoracic L. subclavian TEA	Asymptomatic, 6 months follow-up
8.	F	63	Severe right hand claudication	No pulse R. arm	Long stenosis R. subclavian	R. carotid-brachial bypass	Complete return of function R. arm, 6 months follow-up

R=right; L=left; BP=blood pressure; TEA=thrombo-endarterectomy

utilizing autogenous saphenous vein. One patient undergoing carotid-subclavian bypass also had a concomitant carotid bifurcation endarterectomy because of an ulcerated, atheromatous lesion. In both patients with carotid saphenous vein bypass operative arteriograms were made to insure technical adequacy.

The eight patients were followed for periods of six to thirty-six months.

Results

There were no operative deaths or major post-operative complications. Patients who were operated upon for hand and digital ischemia or arm claudication or both, had complete relief within a week after operation and there was no recurrence. Blood pressure in these extremities has returned to normal, function of the hand has returned, and gangrene of the fingertips noted in Case 6 was completely reversed.

Patients with symptoms of cerebral ischemia were also relieved in all cases; there were no further syncopal attacks, vertigo, or intermittent paresis, and improvement in vision in the ipsilateral eye was noted in both patients who said it was a major symptom. Radial pulses returned in all these patients and blood pressure returned toward the level of the opposite arm in all cases. There has been no return of symptoms during the follow-up period.

Illustrative Case Reports

Individual case reports illustrate some important clinical and therapeutic points.

Case 8 (Table 1). A 63-year-old woman noted increasing inability to use her right hand in performing household chores. She could not write her name without stopping to rest, nor could she wash her dishes without stopping several times. She also complained of similar but less

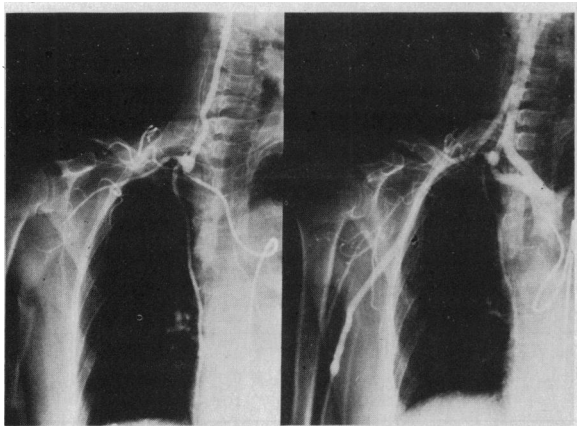


Figure 1.—Selective innominate arteriogram before and after right carotid-brachial saphenous vein bypass in Case 8 (Table 1). The subclavian artery on the left is also diffusely narrowed; the right brachial artery can be seen to fill faintly in the distal arm. Postoperatively, on the right, the saphenous vein graft fills after injection into the common carotid artery.

severe symptoms in her left hand. Her right hand was pale and cool, and there was no radial pulse; a 1+ radial pulse was felt in the left hand, and blood pressure in the left arm was 100/60 mm of mercury. An arch aortogram (Figure 1) revealed diffuse narrowing of the first and second parts of the right subclavian artery as well as the axillary and proximal brachial artery. A right retrograde brachial arteriogram clearly demonstrated patent distal brachial circulation.

After ascertaining that the right common carotid bifurcation was free of atherosclerotic obstruction, a saphenous vein common carotid distal brachial bypass graft was performed under general anesthesia and systemic heparinization. An internal shunt was used during the carotid anastomosis, which was made end-to-side with running 6-0 Tevdek® suture. The graft was tunneled subcutaneously across the clavicle to the distal one-third of the upper arm, where the brachial artery had been exposed. The graft was then sutured end-to-side with running 6-0 Tevdek to a normal brachial artery.

A postoperative arteriogram showed the vein graft patent (Figure 1). Postoperatively, the blood pressure was 140/80 mm in the right arm, the color improved substantially, and within ten days the patient was able to do all her housework without difficulty. After the operation there were no cerebral insufficiency, visual or vertiginous symptoms.

Case 6 (Table 1). A 73-year-old woman presented with early gangrene of the left index finger and severe ischemia of all her left fingertips of about two weeks' duration. She had been a heavy smoker but had stopped two months before admission. She denied any traumatic accident. She had no pulses or blood pressure in the left arm and her index finger was cold, blue-black and extremely tender.

An arch aortogram and cerebral angiography showed 90 percent stenosis of the origin of the left subclavian and of the origin of the left vertebral arteries (Figure 2, *left*). There was a suggestion of an ulcerated lesion of the left internal carotid artery at the left carotid bifurcation by selective angiograms (Figure 2, *center*). Palpation of the left carotid bifurcation confirmed a significant atheroma consistent with the radiologic lesion.

Left carotid bifurcation endarterectomy and saphenous vein carotid-subclavian bypass in the neck were performed under general anesthesia and systemic heparinization. During the carotid occlusion, an internal shunt was used.

Postoperative angiography indicated a satisfactory technical result (Figure 2, *right*). By the end of the first postoperative week, the gangrenous changes had completely resolved and the patient had pulses and equal blood pressure in the arm. She had no postoperative neurologic sequelae.

Comment: It is postulated that obstruction of the ipsilateral vertebral artery precluded any "subclavian steal" and any increase in collateral flow to prevent ischemia of the fingers.

Case 7 (Table 1). A 37-year-old housewife with discoid lupus complained of vertigo with exercise of her left arm, occasional diplopia, and a general decrease in the vision of her left eye during the six months before admission. There was a 1+ pulse in the left arm and lower blood pressure in that arm than in the right.

An arch aortogram and cerebral angiograms showed 90 percent stenosis of the left subclavian artery at its origin (Figure 3). There was radiographic evidence of subclavian steal since retrograde left vertebral filling could be seen in late films of the angiogram series. There was no other abnormality of the cerebral or extracranial circulation.

Because of her age and the possibility of arteritis secondary to the lupus, left thoracotomy

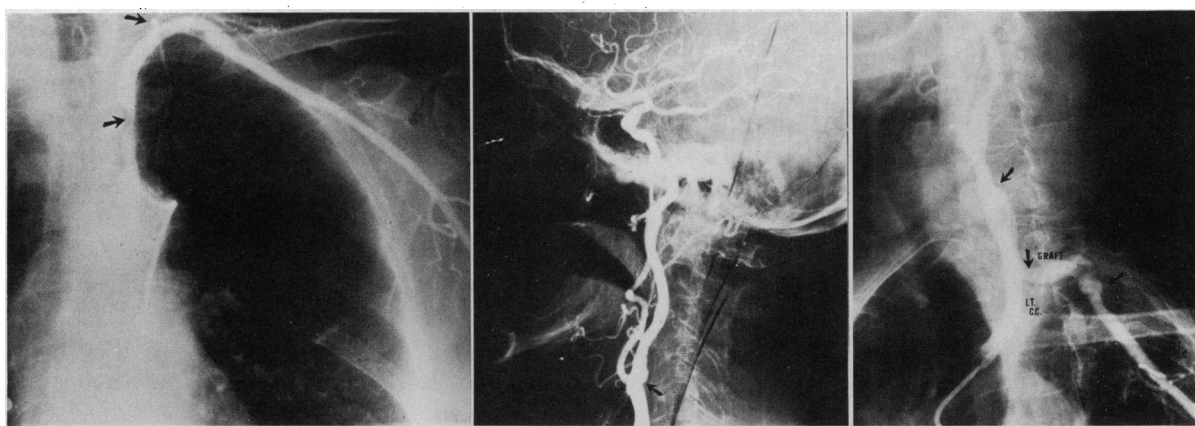


Figure 2.—*Left*, selective left subclavian arteriogram in Case 6. Arrows point to the 90 percent stenosis of the proximal subclavian and the takeoff of the left vertebral. *Center*, selective left carotid injection demonstrating an ulcerated atheroma in the left internal carotid. *Right*, postoperative selective angiogram of the left common carotid artery (LT. C.C.). The three arrows point to the origin, course and termination of the carotid to left subclavian (LT. S.C.) venous bypass graft.

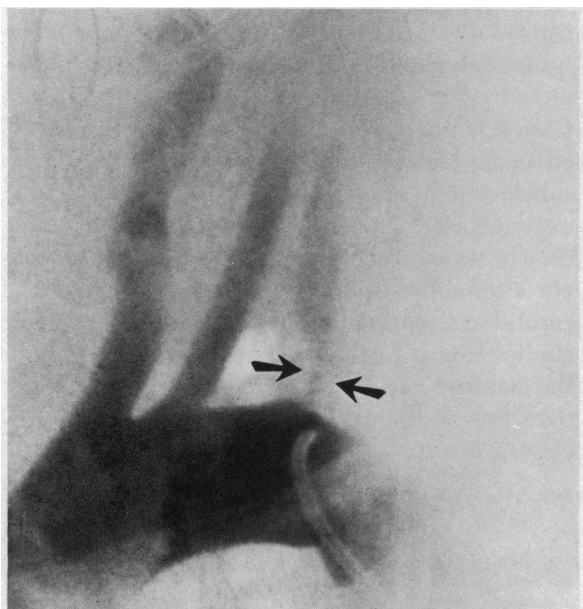


Figure 3.—Aortic arch angiogram in Case 7, illustrating 90 percent stenosis of proximal left subclavian artery.

and left subclavian endarterectomy were performed. A thick atheromatous core extending into the aortic arch was removed through a longitudinal incision in the proximal left subclavian artery. The arteriotomy was repaired with running 5-0 Tevdek. There was no evidence of arteritis either grossly or by microscopic sections. The patient made uneventful recovery, pulses and normal blood pressure were restored in the left arm, and she noted immediate im-

provement in the vision of her left eye. In seven months of follow-up she had no recurrence of vertigo or diplopia.

Comment: An unusual case because of atheromatous disease at age 37 and the presence of severe cerebral symptoms with a solitary subclavian lesion without carotid obstruction.

Discussion

The cases summarized here serve to point out the distinctive, easily reversible syndromes associated with atherosclerotic lesions of the subclavian artery. Ischemia of the hand and forearm in the absence of ischemia of the hindbrain may vary a great deal in severity and the symptoms often pose a problem to the clinician as to when to investigate and treat. Our policy has been to recommend diagnostic workup and surgical therapy if the patient is a reasonable risk in other respects, and if the ischemic symptoms of the forearm and hand are severe enough to interfere with normal activity, as in Case 8. Clearly, the other end of the spectrum, as illustrated in Case 6, offers no problem in management and workup, and operative therapy should be carried out as soon as possible. If significant, discrete stenosis is demonstrated by angiograms, we believe the direct surgical approach by the carotid-subclavian bypass operation or endarterectomy is preferable to cervical sympathectomy.

The problem of the ischemic hindbrain in conjunction with a discrete proximal subclavian

lesion is somewhat more nebulous. The so-called "subclavian steal," a siphoning of blood from the circle of Willis down the ipsilateral vertebral, is usually associated with a decrease in peripheral resistance distal to the subclavian arterial stenosis, that is, in the exercising muscle of the forearm. The syndrome was named by Fisher¹ in an editorial commenting on two cases studied by Reivich et al in 1961.² Contorni³ first described this syndrome in the modern literature but according to Fields,⁴ it was Smyth who, in 1864, made the first reference to the possibility of retrograde flow via the vertebral into the distal subclavian beyond a more proximal occlusion. Certain interesting observations about this syndrome have recently been made by Ehrenfeld, Chapman and Wylie.⁵ In the great majority of their cases the subclavian steal is either asymptomatic or associated with internal carotid artery obstruction, and when the carotid obstruction is cleared, despite the persistence of the subclavian steal radiographically, the patients usually become asymptomatic; only 33 of 125 patients (26 percent) had isolated subclavian steal with symptoms severe enough to require operation.⁵

The exact reason why patients with otherwise normal cerebral and carotid circulation have the clinical effects of subclavian steal with an isolated subclavian stenosis must lie in peculiarities of the circle of Willis. Eklof and Schwartz,⁶ in an elegant canine experiment, showed that cerebral blood flow, electroencephalogram or cortical oxygen tension was not changed with the subclavian steal, even with vasodilatation of the ipsilateral forelimb. These findings emphasized the autoregulatory capabilities of the cerebral circulation, a phenomenon that probably accounts for the clinical observation that it is unusual for the subclavian steal *per se* to result in cortical cerebral ischemia. This observation correlates with the clinical observations of Ehrenfeld et al.⁵ Three patients in our series had a solitary subclavian lesion without other obvious cerebral obstructions. More careful radiologic delineation of the entire circle of Willis may demonstrate abnormalities of the posterior communicating vessels in these and future patients to explain the clinical findings. Indeed, Lord, Adar and Stein⁷ showed evidence of disconnection of the circle of Willis between the territories of the carotid and vertebral arteries in a significantly higher proportion of patients

with vertebrobasilar insufficiency and the subclavian steal syndrome.

Operation for lesions of the subclavian artery has undergone a gradual evolution from procedures necessitating thoracotomy to those requiring cervical bypass.⁸ Crawford et al⁹ reported that the mortality with thoracic procedures (thrombo-endarterectomy or aorto-subclavian bypass) during the first years of their series was 20 percent; with extrathoracic procedures for similar lesions, the mortality has fallen to less than 3 percent. Similarly, Ehrenfeld, Chapman and Wylie⁵ noted a 9 percent mortality after the transthoracic approach in 14 patients.

Other than for diagnostic indications (Case 7), or in conjunction with an additional intrathoracic cardiovascular procedure, our current treatment of choice is the transcervical saphenous vein bypass grafting from the common carotid distal to the subclavian obstruction. The ipsilateral carotid bifurcation thrombo-endarterectomy (TEA) is performed, if indicated, as in Case 6. Controversy has existed as to the "steal" effect on the cerebral circulation from carotid-subclavian bypass,¹⁰ but both extensive clinical experience^{5,8,9} and experimental studies¹¹ have clearly shown that a vascular steal does not occur after carotid-subclavian bypass provided the carotid circulation is unobstructed. Flowmeter studies¹¹ have further demonstrated that flow in the common carotid trunk increases to accommodate the additional circulation to the left subclavian artery.

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